Arms Control Simulation: The Search for an Acceptable Method

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Introduction

Since the earliest times science has served in the cause of war; the discoveries of science have been forged into the most ingenious weapons and their nonmilitary potential sometimes neglected or entirely overlooked. During the past 100 years, we have not only devised ways and means of applying the discoveries of science to the improvement of weapons hardware—the issue that troubles so many of us today—but we have also applied with great success the scientific method to more abstract ways of improving the performance and efficiency of military weapons systems, including, for example, economic analyses, operations research, simulated military operational training exercises, and computerized war games. While many of these nonphysical scientific techniques are probably applicable to the problems of world peace, particularly arms control, little has been done to rework the technology and apply it to areas serving the cause of peace.

At the same time, no physical or social scientist who has waded through the arms control literature of the past three years can fail to note the lack of controlled research and the appalling absence of hard data. If we are to avoid being buried under a mountain of nothing but "words, words, words"—to use Hamlet's phrase—we must seek and find an acceptable research methodology for studying problems of national strategic planning, particularly arms control. Since the problems of peace and war, military and political strategy, have many characteristics in common including complex interactions of elusive social-psychological variables, difficulties of experimental control, etc., it is not unreasonable to ask whether some of the methods commonly applied to the study of war may not be applicable to the broader set of problems covered by the concept of national strategic planning.

One area which seems to offer particular promise for the purpose of national strategic planning is "war gaming." While most war gaming techniques are firmly rooted in the past, going back at least to the 17th Century, recent developments have had a marked effect on the possibility of their more general applicability, particularly the use of high-speed digital computers. Let us examine both the techniques and their historical antecedents in an effort to isolate some of their advantages and disadvantages and determine their possible utility for studies of arms control. An illustration of the application of one of these techniques (environmental simulation) to the arms control area will be developed in some detail.

Five Alternative Methods For Military Planning

1. *Individual and Group Planning.* Prior to the 17th Century, strategic planning was carried on by individuals and/or groups. It

is a commonly noted fact that individuals and organized groups tend to be partisan; their perceptions are determined by their past experience, motivations, and the social groups to which they belong; and it is often difficult for them to project themselves into the roles of others.

The individual, working in isolation, lives in a world narrowly circumscribed by his own psyche; his views and opinions must be filtered through many layers of social conditioning before he is even aware of them. For the individual, "thinking like the adversary" requires a complete cognitive reorganization—a reorganization which can only be accomplished by resolving all the inconsistencies which inevitably arise when two opposing views are laid out side by side. As Charles Osgood (1960) has noted, the weight of the evidence indicates that under such circumstances individuals follow the paths of least resistance, and dissonant ideas tend to be reorganized and reinterpreted in terms of established modes of thought.

When individuals are members of groups which already have firmly established prejudices, it is very difficult for them to stand against the tide of group opinion. Indeed, a large body of small group research has shown that individuals commonly conform to the opinion of the group even in the face of clear-cut and objective evidence to the contrary (Asch, 1956; Sherif, 1956). When the alternative to conformity is to be seen as a deviant by the group to which one belongs, the pressures are very great to go along with the others and many people simply comply (Festinger, 1951; Siegel and Siegel, 1957). Furthermore, the individual who thinks like the adversary in the presence of his peers may be seen by those around him to be in sympathy with outsiders. Thus, individual and group planning is often controlled by psychological and social pressures which encourage the selective and biased consideration of particular ideas.

One strategy for minimizing such selectivity is for the group to encourage "role playing" and for the individual to force himself to see the world from the point of view of others in a permissive atmosphere. Role playing is at best only a partial solution, for its success depends primarily upon our ability to see ourselves as others see us and to see others as they see themselves—a very difficult thing to do. To the extent that realism can be introduced by simulating environmental factors, however, it may be possible to enhance objectivity.

A second problem with individual and group planning is the inability of individuals to clearly visualize alternatives and constraints. In the early history of war gaming, this problem led to the development of chess-type boards and sand tables. Today, the need to visualize alternatives has resulted in the construction of complex models (both physical and abstract) for simulating force structures, economies, etc.

Let us consider the evolution of some of the early ideas which influenced the subsequent development of war games so that their possible application to the study of other areas can be better understood. Efforts to motivate officers to "role play" realistically led to the development of other aids for lending realism to games. Elaborate rules were developed for the calculation of such factors as troop movement, fatigue, effects of fire, and casualties. At first, many of the calculations were purely theoretical, but gradually the inventors of new games turned to empirical data derived from actual battles to construct their tables. Games following this tradition generally fall into the class known as Rigid Kriegspiel. In view of the lack of sophisticated data-processing equipment available at the time, it is not surprising that Rigid Kriegspiel was seldom played according to the rules and was frequently disliked by officers required to play it. In describing Livermore's American Kriegspiel, for example, Sayre (1911) states: "It may be confidently stated that Colonel Livermore's system is the best of its class, but it cannot readily and intelligently be used by anyone who is not a mathematician, and it requires, in order to be able to use it readily, an amount of experience, instruction, study, and practice about equivalent to that necessary to acquire a sure knowledge of a foreign language."

Its critics pointed out that the rules were not only tedious and difficult to learn, but caused inordinate delays in the conduct of the game so that both continuity and interest were lost. Many of the objections to Rigid Kriegspiel have now vanished as a consequence of the development of the general purpose digital computer, and computerized war games tend to be in the tradition of Rigid Kriegspiel. New objections, however, have arisen in their stead, having to do with the assumptions and values buried in the programs of the computer.

Free Kriegspiel was a protest against the formality of Rigid Kriegspiel. Its proponents argued that Rigid Kriegspiel was "too great a strain on the patience." Free Kriegspiel relied on the judgment of experienced officers for the conduct of the game and decisions regarding rates of troop movement, casualties, etc. Its opponents pointed to the inevitable problems associated with getting reliable and valid judgments under such conditions, but Free Kriegspiel took hold and was the more widely played of the two until after World War II.

These two streams of thought (Rigid and Free Kriegspiel) have led to the development of the remaining four approaches to strategic military planning. In discussing these, the distinctions and similarities between Free and Rigid Kriegspiel are well worth keeping in mind. Arguments for using empirical data and fixed decision rules parallel those of the proponents of Rigid Kriegspiel; arguments for employing experts, however, do not have to do with expediting the game since, as indicated, such arguments are no longer as valid as they were before the invention of the digital computer. Instead they are related to the general problem of preserving the range, complexity, and richness of variables when problems of this scope are studied.

2. *Scenarios.* Even if one is able to achieve a degree of objectivity and see the world as his opponent sees it; and even if one is able to visualize many of the alternatives, a third serious problem presents itself for individual and group planners. Namely, what conditions and constraints determine the point of departure for planning and the subsequent general flow of ideas? How is the universe of discourse to be controlled and directed? One very effective way of doing this is through the use of scenarios. A scenario traces out that which may someday come to pass; it is a fairly detailed description of one of the many possible paths down which the forces of history may lead us. Scenarios are often used as game aids or they may be used as a self-contained technique for studying a particular problem. As aids, they provide a point of departure and focus the attention of participants on a particular set of problems throughout the problem-solving period.

But in addition, the task of writing a detailed scenario can, in and of itself, be a very useful and productive exercise. Herman Kahn (1962) has described two scenarios of this kind in his most recent book. When seen as an aid to thought, particularly for the development of new hypotheses which might not otherwise be noted, the technique can be quite useful. Like the more sophisticated games in which they are often used, scenarios raise numerous questions regarding the interactions of complex social, psychological, political, and military factors. Because a scenario describes a hypothetical series of events, possible consequences of a given course of action become more apparent and planners of events are forced to deal with problems which, for the social and psychological reasons previously discussed, an individual or a group might otherwise avoid. The violent and emotional uproar created by Kahn's efforts to trace out the consequences of various kinds of conflict (Kahn, 1960) illustrates how powerful these social-psychological forces can be when accepted modes of thinking are seriously disturbed by unconventional ideas. We find it equally difficult, of course, to tolerate an objective analysis of such "unthinkable" ideas as strategic surrender—even though the cost of surrender in human misery might be less than the cost of a nuclear exchange. Indeed, the furor created by Kecskemeti's analysis of this problem (Kecskemeti, 1958) illustrates nicely the reasons why one is sometimes forced to turn to the more "permissive climate" of a game in order to encourage objective analysis.

3. *Crisis Games.* Individuals acting alone can develop scenarios. Crisis games, on the other hand, require two or more "actors" who play the role of aggregated real-life counterparts, such as the United States or the U.S.S.R., NATO or the Warsaw Pact countries, and even "nature." A key element in crisis gaming is role playing. At the simplest level, no effort is made to simulate the environment in detail.

Both the Germans and Japanese are known to have used crisis games prior to World War II. Eric von Manstein reports in some detail on a political-military game played by German officers and civilian diplomatic officials in the years prior to World War II. Von Manstein is quoted by Goldhamer and Speier (1959) regarding the value of the game: "We had the impression also that the gentlemen from the foreign office to whom such playing-through of possible conflicts seemed to be completely novel, were thoroughly convinced of the value of the game."

Rear Admiral Zacharias, who lived for many years in Japan prior to World War II, reports that similar crisis games were played by Japanese military leaders (Zacharias, 1961), and further evidence regarding the conduct of such games was introduced at the Tokyo War Crimes Trials.

One of the most serious problems in connection with such games lies in the use of individual actors to portray highly aggregated entities such as nations, military blocs, or even nature. This criticism can also be leveled against similar mathematical games played without human participants in which the aggregated entities are simply "swept under" the computer programmer's rug. Advocates of the analytic approach sometimes cite their clearly defined assumptions as almost *prima facie* evidence for the superiority of mathematical and computerized games over crisis games employing human actors. The belief that the validity of one approach vis-à-vis another can be decided by "the elegance of the method" is not particularly compelling, however.

Furthermore, one should not underestimate the degree of precision demanded by crisis games. When experts are assembled together and given sharply defined roles, explicit statements of their assumptions will be required to defend their arguments and actions (Goldhamer and Speier, 1959). Out of these confrontations frequently come new ideas and hypotheses which may later be examined by individual or group analysis.

4. *Symbolic Simulation.* Simulation for the purpose of studying political and social phenomena involves the construction of models and the movement of models through time. When one uses symbolic simulation, the models are either logical or mathematical. Abt (1962) has recently described an interesting game of this kind which appears to have clear-cut arms control implications, but detailed information about the game is not yet widely available.

If the construction of models for symbolic simulation involves the incorporation of strictly mechanical and stochastic processes, precise definition of variables is generally possible. It may, however, involve symbolic representations of human behavior or human organizations, in which case the problem is far less manageable.

However powerful the method or machines, real-world alternatives cannot be predicted or evaluated if we are unable to define precisely the relevant variables and their interactions, and operationally relate them to the real world. Cause and effect relationships must be known. Human interactions pose a particularly serious problem in this regard. Where human behavior in a system is routinized and rigidly bounded, the use of symbolic simulation may be appropriate. To the extent that human behavior is not so routinized or bounded, it becomes less predictable and doubt arises regarding the utility of symbolic simulation.

It is sometimes argued that symbolic simulation provides new insights for those involved in the construction and employment of the models, and it seems reasonable to suppose that this is the case. If this is the purpose, however, the criteria for evaluating symbolic simulation change. If the objective is training, rather than predictive efficiency, one would want to know, for example, who is being trained, whether transfer will be positive or negative, and whether this method is more efficient than others.

5. *Environmental Simulation.* It is commonplace observation that the world we live in is enormously complex. Where lawful relationships do exist, they are frequently disguised from the casual observer. We seek to unravel the simplest thread only to find that it binds together an enormously complex array of interdependent events. The classical experimental method of 19th Century physics, which is still widely used in the behavioral as well as the physical sciences, involves efforts to abstract away much of the complexity of the world. Reichenbach (1951) describes the process as follows: "The scientific experiment isolates the factors from each other; the interference of man creates conditions in which one factor is shown at work undisturbed by others, thus revealing the mechanism of the complex occurrences that happen without man's interference." Unfortunately, the frequency of interactions between political, social, and psychological variables is so great as to place a limit on the usefulness of this approach for the experimental study of complex processes of the type we are now discussing. An alternative method is environmental simulation.

Environmental simulation seeks to preserve the complexity of the environment, rather than abstract it away. When using environmental simulation, the experimenter tries to maintain the richness and variety of the environment and allows human participants to respond to a situation which resembles as nearly as possible "real life." Both the more traditional social-psychological experiment and environmental simulation involve measuring human actions—one in an abstract environment which bears little resemblance to the real-life situation, the other in a more complete replica of its real-life counterpart.

There are a number of examples of this kind of simulation including studies of international relations (Guetzkow, 1959), the stock market (Kennedy, 1962), and air defense (Chapman, *et al.*, 1959). An arms control study using environmental simulation was conducted by Carpenter and the author some months ago. This study highlighted some of the differences between the more traditional experimental approach and environmental simulation.[1] It was designed to test manually the feasibility of building a more complex computerized version of the arms control game. Before describing the game in detail, it may be worthwhile to pause and consider the kind of problem it is designed to study.

The United States and U.S.S.R. are required to make regular decisions regarding allocation of their resources. In doing this, each nation responds to intelligence about the other and the world in general. Any arms control agreement signed in the near future would presumably contain provisions for changes in the behavior of both countries (arms controls) and a means of determining whether such changes had indeed taken place (inspection). Numerous information channels would provide the two nations with information about one another. The treaty would probably allow some degree of formal inspection, perhaps by on-site observers and/or by aerial overflights or other techniques. In addition, intelligence would be received from more informal and sometimes even routine channels such as attaché reports, newspaper articles, tourist observations, etc.

When these assumptions are tied together, the general pattern which emerges is one of dynamic interaction. Since arms control agreements, of necessity, would be implemented over a period of years, the picture is one of two or more nations gradually modifying their economies and military forces as a consequence of their confidence, or lack of confidence, in the intentions of other nations. If one could construct a suitable data base representing the military, production, and manpower resources of each of the countries, it would be possible to study the kinds of decisions made by national leaders and their consequences as a function of various treaty provisions. One key provision would deal with the inspection resources permitted to each side. In addition to treaty-provided inspection, other more informal sources of intelligence do exist. The optimal use of these two kinds of intelligence resources is, of course, very critical. Thus, for example, if the treaty allowed 20 on-site inspections and 7 aerial overflights per year, decisions regarding use of these intelligence allotments, along with an analysis of informal inputs, would have a direct bearing on the question of whether or not cheating would be detectable and possible counteractions that might be taken. An adequate game—particularly one with a large enough data base—could be used to study the kinds of decisions made for various treaty provisions and the consequences of these decisions. Given these conditions, we constructed a game which had the following characteristics.

During the course of the game, the experimenters were interested in two kinds of behavior: the way in which each side modifies its data base as a consequence of intelligence received, and the way in which each side expends its treaty-provided intelligence resources.

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[1] The description of an arms control game which follows is taken in large part from a paper by P. B. Carpenter and R. H. Davis entitled, "Arms Control Simulation: An Empirical Approach," presented at the meetings of the American Psychological Association in September, 1962, at St. Louis, Missouri. In an effort to construct an economical version of the game, many of the required models were greatly simplified; details of a more complete and somewhat different version may be found in Davis, *et al.* (1961).

Since the construction of a data base describing in detail the military, industrial, and human resources of both the U.S.S.R. and the United States would be a very expensive undertaking, we decided to devise a more modest version consisting only of military force units.

A Blue team (United States) was organized. This team consisted of three subjects, all of whom were charged with making decisions which they felt were in the best interest of their country: a national leader, a military leader, and a civilian leader. The military leader had, in addition, the responsibility for keeping the country safe from an expected or a surprise attack; the civilian leader had the additional responsibility of spurring the economy through tax cuts or other measures all of which depended upon disarmament for funding.

In order to conserve manpower and to provide experimental control, decisions of the Red team (U.S.S.R.) were scripted to follow precisely the provisions of a disarmament proposal. That is, Red complied with all treaty provisions. Since there were no direct contacts between the two teams, the passive nature of Red and its compliance strategy were unknown to Blue. The general structure of this game is illustrated in Figure 1. Observers monitored the game from an adjacent room. Using special aids and a desk calculator, they computed game results on a cycle-by-cycle basis.

The Blue team had the following basic tasks to complete during each cycle:

1. To review and evaluate the latest intelligence reports;
2. To review strategy;
3. To specify changes in the composition of their armed forces;
4. To assess the effects of changes on their strategic and limited war capabilities vis-à-vis Soviet capabilities.

The models and game aids used were designed to create a high degree of realism and to facilitate the play of the game. These included a disarmament proposal, inventories of United States and Soviet armed forces, an aggregated economic model, an intracountry conflict model, an intercountry conflict model, assessment models of limited war strength and strategic war strength, and finally, an intelligence model.

The disarmament proposal imposed on this game was a highly abstracted version of the proposal that President Kennedy presented to the U.N. in September, 1961. This proposal called for reduction of weapons and of nuclear delivery systems through three phases.

The United States weapons systems inventory contained a list identified by name or number, e.g., the 101st Airborne Division. Identification numbers did not necessarily refer to their real-life counterparts. These systems were aggregated to the division, wing, squadron, or capital ship level. Acquisition and maintenance costs for each system were listed and entered into the operation of the economic model.

The Soviet weapons systems inventory contained a list identified by number to the same degree of aggregation as for the United States weapons systems.

The economic model was aggregated, dealing with the Blue team's gross national product, its rate of growth, and the tax base.

The intracountry conflict model established the roles of the three players on the United States team as described above. In addition, a payoff pool was created to enhance both team motivation and individual

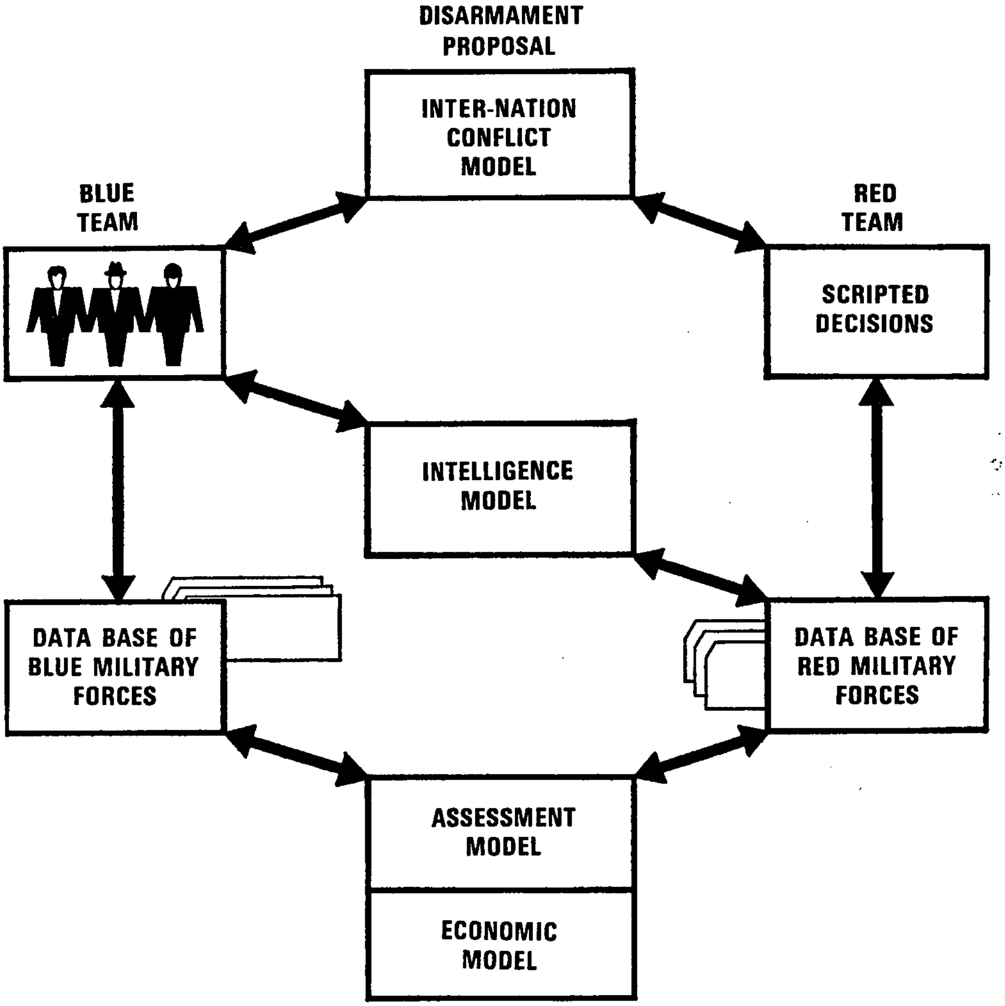

FIG. 1. Structure of the game.

competition within a team. Players could enlarge the payoff pool at a specified rate by disarming or by using money saved from disarmament to stimulate economic growth at a rate faster than expected. The national leader automatically received one-third of the payoff pot. The military and civilian leaders divided the remainder of the payoff pot according to how well each played his role. The more military force retained by the team, the larger the military leader's share of the pot and the less received by the civilian leader. Conversely, more and faster disarmament increased the civilian leader's payoff and reduced the reward for the military leader. Even under these mild motivational circumstances, the civilian leader seemed to regard the competing military leader as a warmonger, and the military leader seemed to see the competing civilian leader as soft on national security.

Preparing subjects to participate in the game took a half day of training. One of the concepts most difficult to communicate was the notion that this was a non-zero-sum game. Possible outcomes were relative stability and moderate to high payoff to both teams; or instability, nuclear war, and virtually no payoff to either team. Description of the intercountry conflict model may clarify this point.

The outcome of the intercountry conflict model was partly determined by the actions of players and partly stochastic. Subjects had major control over the occurrence of strategic war in that the probability of strategic war increased with each game cycle that the arms level increased or remained constant. Strategic war also would occur in the event of gross differences in force structure (instabilities). This was left undefined to subjects, but was arbitrarily set at a 100 per cent difference in force capability. The occurrence of a strategic war had the immediate effect of reducing the value of all game assets, military and economic, by 50 per cent. (The payoff pot was also reduced by 50 per cent.) Then the remaining strategic war capabilities were subtracted from one another. This difference was added to the victor and subtracted from the loser. Thus, the cost of strategic war was inordinate, but victory, while Pyrrhic, remained more desirable than defeat. Occurrence of strategic war also ended the game after these prior calculations had been made.

The occurrence of limited war was not under the control of the team. Limited wars occurred by chance and at any time. The cost of limited war was only 10 per cent of the military assets. Limited war also required a confrontation between the limited war strength of the two teams with the stronger team gaining and the weaker team losing the difference between their respective limited war strengths.

The assessment of strength inherent in different military postures is very difficult and remains contentious. Resolution of this issue became critical to the game because the key concepts of military stability and instability necessitated an assessment procedure. Our solution (Carpenter and Davis, 1962) to this problem was to have 100 weapons systems experts rank the relevant weapons systems for utility, once for strategic war and once for limited war. Scaling techniques were then used to place these weapons systems on equal interval scales, one for strategic war and one for limited war. These scales were the basis for our military assessment models (Figure 2). After taking into account differing utility for any particular weapon as the numbers of that weapon increased, summing the values of all the weapons in the inventory provided a single value for either strategic or limited war capability.

In designing this game, a number of possible independent variables were taken into consideration. These included the disarmament proposal, with attendant details such as the level of disarmament and the possible phasing of it; intelligence, with its attendant details such as quantity, quality, frequency, and source; and subject instruction with regard to strategies, tactics, treaty observations, and intrateam conflicts. These variables were held at constant values throughout our several games except for the amount of intelligence available to the team.

The intelligence model provided two different kinds of intelligence, covert and treaty directed. The covert intelligence reports occurred every other cycle and contained mostly general information. Treaty-directed information, the second kind of intelligence, was the only independent variable which was varied. One run of the game employed a high information condition which identified 10 active and 10 disarmed units from the Soviet armed forces. Another run of the game employed a low information condition

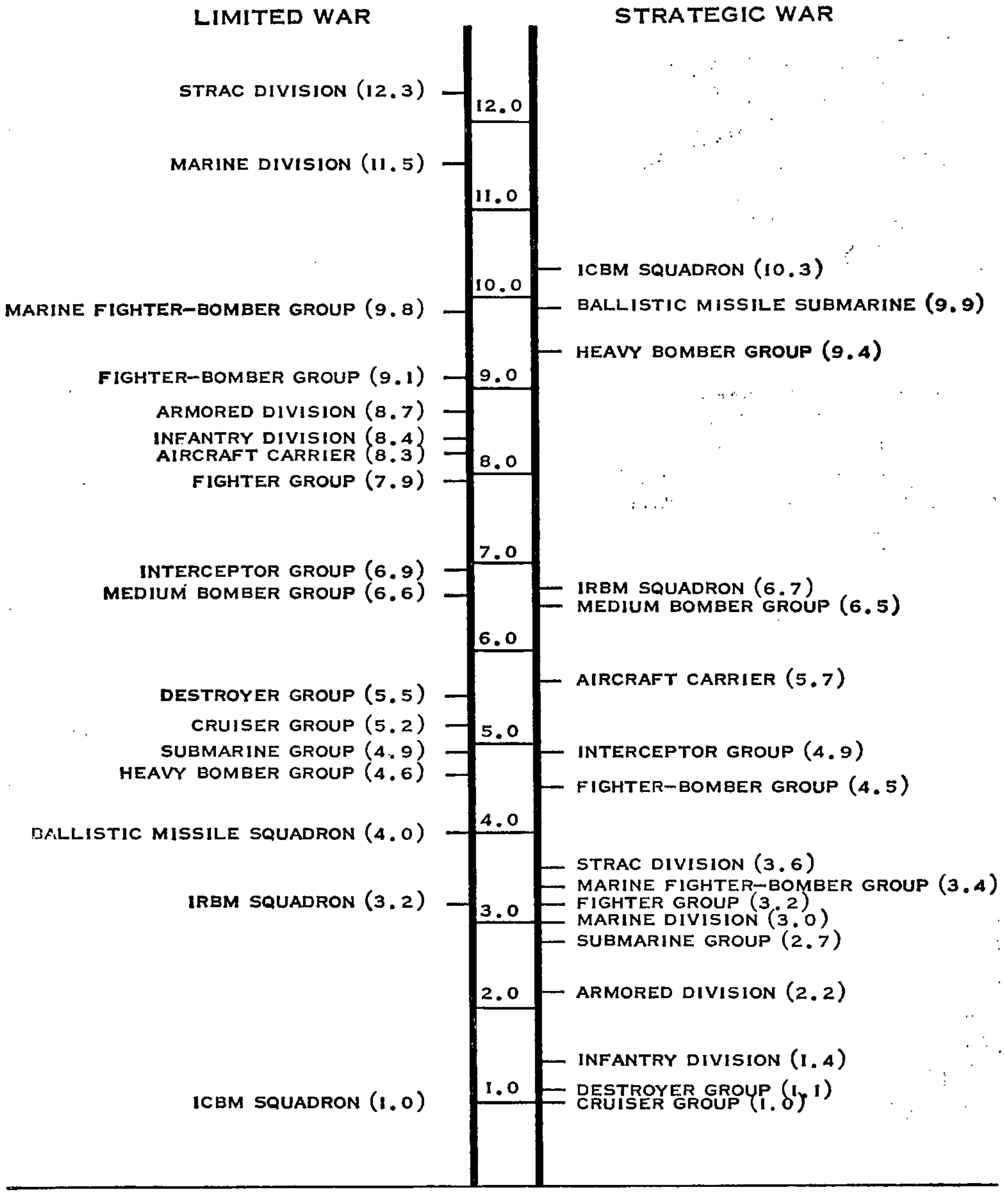

FIG. 2. Scale values for 17 weapons systems for a limited and a strategic war ranked by 100 experts.

which identified only five active and five inactive units from the Soviet armed forces.

The game described here represents an evolutionary development. The present version is at least the third. Our last effort with this version was to run several feasibility exercises. Analysis of these exercises indicates that this version of the game is internally consistent, has "face" validity, at least, and is quite playable. Further, it does

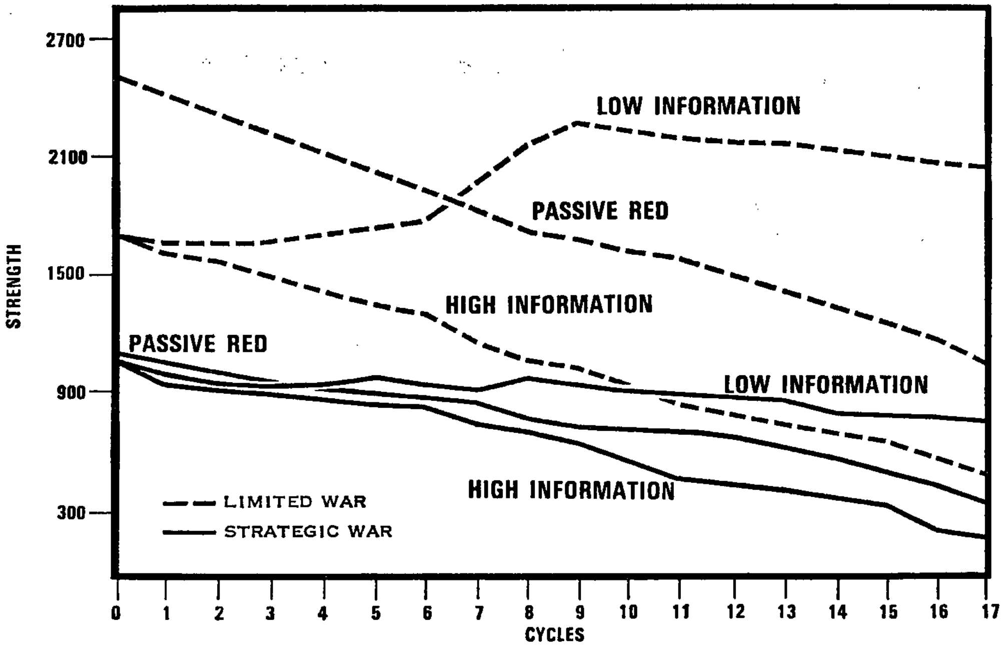

FIG. 3. Strategic and limited war strength plotted as a function of game cycles for passive Red and active Blue under two information conditions for Blue (high and low).

not require extensive facilities or a computer, although use of a computer would permit faster play with more complex and adequate models.

The present version of the game was run twice, once with high information available and once with low information available, so it is apparent that the results cannot be generalized although they do provide stimulation for thought.

The top solid line of Figure 3 describes the effects of the disarmament of the low information United States team on their strategic war capability. This team, with its limited information, remained quite distrustful of the Red team, particularly of their limited war capability. They adopted a strategy of disarming very slowly over-all by reducing strategic capability moderately and replacing much of the lost strategic capability with limited war capability.

The bottom solid line of Figure 3 describes the effects of high information on the United States team's disarmament of their strategic war capability. This team became convinced that the Red team was disarming honestly and in accordance with treaty specifications. The United States team became concerned that its good intentions might not be recognized by the Red team. To meet the objective of communicating their sincerity, this team disarmed much more rapidly than was called for by the disarmament proposal. According to the provision of the internation conflict, these conditions led to strategic war.

The top dashed line of Figure 3 describes the effects of the low information United States team's disarmament on their limited war capability. Continued suspicion and intransigence on the part of this team resulted during cycle 17 in a military posture that was twice Soviet capability for strategic or limited war, and thereby was responsible, according to our intercountry conflict model, for a strategic war.

The bottom dashed line of Figure 3 describes the effects of the high information United States team's disarmament on their limited war capability. By coincidence again on cycle 17, the consequences of this team's strategy resulted in the Soviet strategic and limited war capabilities both being twice the respective United States capability. Again the consequences were by definition a strategic war.

Since subjects ranked weapons separately for either a strategic war or a limited war, the perceived values of various weapons apply to these two types of war only and not to perceived utility for any war. Comparisons of strength, therefore, must be drawn separately between high and low information in the case of limited war (dashed lines of Figure 3) and high and low information in the case of strategic war (solid lines). Both limited and strategic war data, however, can be combined if a concept like "force units" is introduced. Force units refer to such items as infantry divisions, missile squadrons, etc. In terms of force units, the per cent of disarmament that occurred for the low information United States team is shown on the top line (Figure 4). The bottom line describes the per cent of disarmament that occurred for the high information team.

When considering these results, it is important to keep in mind the fact that the game described was conducted without replications and focused on the question of feasibility and not validity. As we shall see, the so-called validity issue remains unresolved for both games.

The relationship of all of these methods, scenarios, crisis gaming, symbolic simulation, and environmental simulation to one another has already been discussed. Free Kriegspiel has led to the development of scenarios and crisis games as self-contained approaches to the problem. Rigid Kriegspiel has led to environmental and symbolic simulation. When scenarios and crisis role-playing are seen as aids, rather than methods, they may both be used during environmental simulation; and scenarios may be used during symbolic simulation.

Conclusions

What conclusions can be drawn from this array of potentially useful methods for studying arms control? Are any of them really satisfactory? No matter which of the techniques described we choose to use, including individual or group planning, the "moment of truth" arrives when we try to answer the following question: Has the real system been so violated by our technique that there is not a reasonable degree of similarity between our conceptual model of reality and the real world? Or expressed in another way, does our conceptual model of the world have sufficient relationship to things as they actually are, to allow us to predict real-world events? This is the validity issue.

For the purpose of prediction and evaluation, at least, not one of the techniques described is, in my opinion, adequate; not one of them can be operationally traced back to the bedrock of reality and their utility for prediction and evaluation is therefore questionable. Does this mean we should abandon all attempts to game such complex political problems? Not at all. For one thing, there is no reason to believe that the more traditional approaches such as individual and group planning are necessarily better than simulation and gaming. Although simulation will probably never sup-

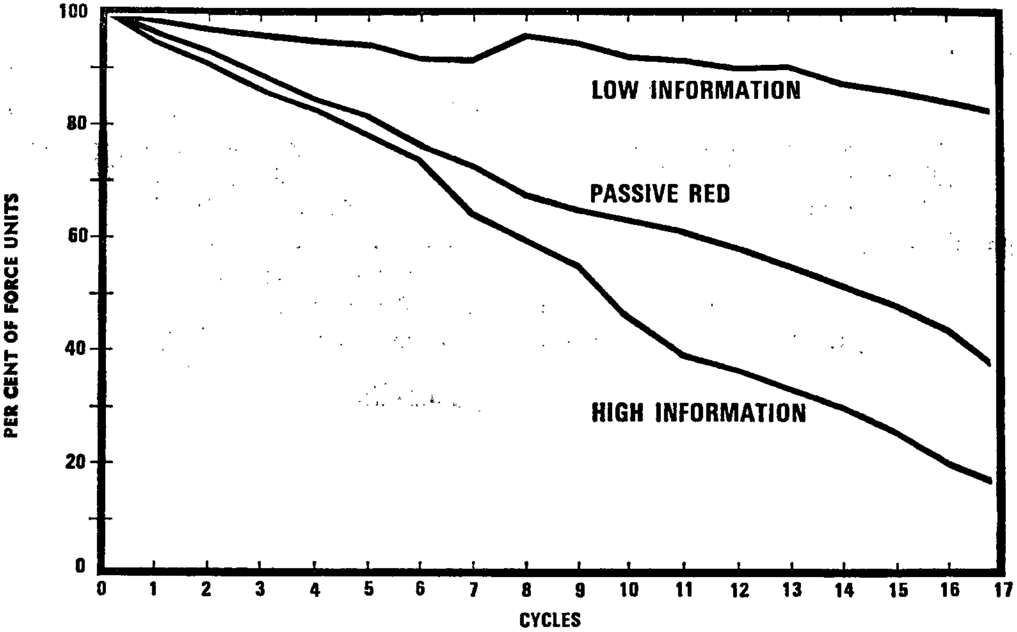

FIG. 4. Per cent of force units (data base items) left to passive Red and active Blue under the two information conditions (high and low).

plant traditional methods, it can supplement them.

The validity problem remains the most difficult one of all and because it is so crucial, we cannot ignore it much longer. As a minimum, it should be possible to test one method against another in order to determine whether they produce similar results. Furthermore, it seems reasonable to suppose that symbolic simulation could be tested against environmental simulation. It should be easier to predict *the results of an environmental simulation* using analytic techniques than the outcome of a similar set of events in the real world. Inputs to environmental simulation games are precisely defined by comparison with the real world. Assessment and other models exist and are readily available for symbolic simulation. Surely predicting the outcome of a laboratory run under such conditions should be easier using symbolic simulation than predicting events in the real world where inputs and models can only be surmised.

But all of this assumes a coordinated effort; it assumes that someone, somewhere, has the resources and authority to study the relationship of isolated research projects to one another in order to determine their reliability, their validity, and their hierarchal relationships.

We should undertake studies of this kind not for the answers they will provide today but because such studies may lead to better methods for solving problems tomorrow. Indeed, the great value of methodology, per se, is that it is devoid of specific contents; it is a means to a solution which—once perfected—can be used over and over again for a variety of problems.